Measurement of Ceramic Thermal Expansion via High Temperature X-ray Diffraction

J.Y. Kim, J. Hanson (BNL), Y. Gao, B. Nyiri (General Electric), and J. Z. Larese (BNL)

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Introduction: Accurate measurements of the coefficient of thermal expansion (CTE) of ceramic materials at elevated temperatures are of very important for many industrial applications. In fact the lack of reliable thermal expansion data has often been the underlying cause of product failure. Dilatometry is commonly used in industry to obtain CTE at high temperatures for ceramic materials. Unfortunately this method only provides information about the average change in the lattice of the material, no microscopic information concerning the changes in the lattice constant of the material is recorded. This is a severe shortcoming when dealing with non-cubic crystalline materials with anisotropic thermal expansion.

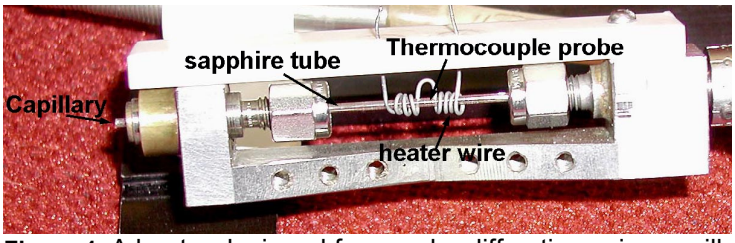

Figure 1. A heater designed for powder diffraction using capillary samples.

Results: Measurement of CTE by monitoring the change in lattice parameters using synchrotron radiation and an area detector appears to be an attractive approach for investigating these materials provided that the required accuracy and precision can be achieved. We have recently designed and tested a kanthal wire based heater system using a sapphire capillary sample stage (shown in **Figure 1**) for use in determining the CTE at elevated temperatures. This new device mounts directly on the goniometer stage of a MAR345 detector system and allows for accurate heating and temperature determination as well as reproducible repositioning of the sample. Y_2O_3 was used as the standard testing material. **Figure 2** plots the mean thermal linear expansion and calculated standard deviation from four different measurements over a two-day period. The measured data is in a good agreement with the known literature values [1].

References: [1] Thermophysical Properties of Matter, Vol. 13: Thermal Expansion – Nonmetallic Solids.

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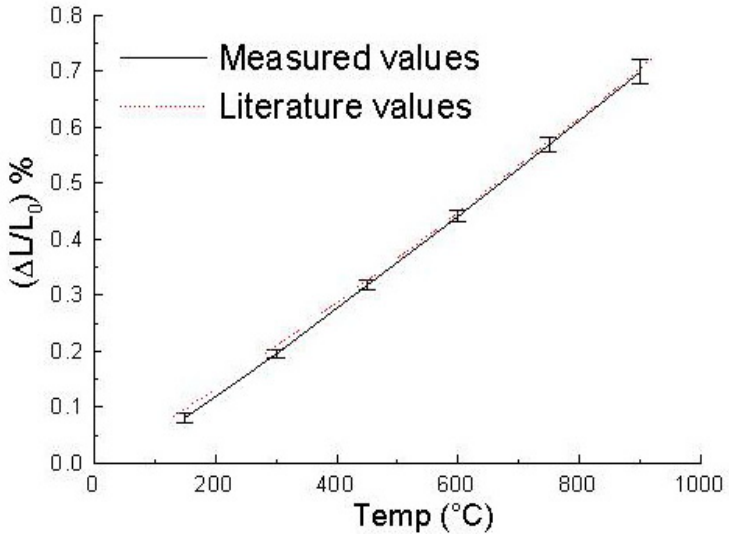

Figure 2. Lattice parameter thermal linear expansion of Y_2O_3. The solid line and error bars represent the mean values and calculated $\pm\sigma$ based on four measurements